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TITLE: **HOT-MELT ADHESIVE FOR**
NON-WOVEN ELASTIC COMPOSITE
BONDING

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CROSS REFERENCE TO RELATED APPLICATION

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HOT-MELT ADHESIVE FOR NON-WOVEN ELASTIC COMPOSITE BONDING

BACKGROUND OF THE INVENTION

5 People rely on disposable absorbent articles to make their lives easier.

Disposable absorbent articles, such as adult incontinence articles and diapers, are generally manufactured by combining several components. These components typically include a liquid-permeable topsheet; a liquid-impermeable backsheet attached to the topsheet; and an absorbent core located between the topsheet and the backsheet. One or more of these components typically includes elastomeric properties. When the disposable article is worn, the liquid-permeable topsheet is positioned next to the body of the wearer. The topsheet allows passage of bodily fluids into the absorbent core. The liquid-impermeable backsheet helps prevent leakage of fluids held in the absorbent core. The absorbent core generally is designed to have desirable physical properties, e.g. a high absorbent capacity and high absorption rate, so that bodily fluids can be transported from the skin of the wearer into the disposable absorbent article.

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20 Frequently one or more elastomeric components of a disposable absorbent article are adhesively bonded together. For example, adhesives have been used to bond individual layers of the absorbent article, such as the topsheet (also known as, for example, the body-side liner) and backsheet (also known as, for example, the outer cover), together. Adhesives have also been used to bond discrete pieces, such as fasteners and leg elastics, to the article. In many cases, the bonding

together of components forms a laminated structure in which adhesive is sandwiched between materials (such as layers of polymer film and/or layers of woven or non-woven fabrics) that make up the components being bonded together.

In many instances, a hot-melt adhesive, *i.e.* a polymeric formulation that is heated to substantially liquefy the formulation prior to application to one or both materials when making a laminate, is used in making a laminated structure. While such formulations generally work, they can be costly and their performance properties can be improved. For example, adhesion can be improved to help provide a sturdier laminate (*e.g.*, to improve the integrity or strength of the bond between two components in a disposable absorbent article).

There is a need or desire for an adhesive composition that possesses one or more performance characteristics that are comparable to, or better than, one or more of the same performance characteristics (*e.g.*, bond strength) of a conventional hot-melt adhesive and that will typically cost less than a conventional hot-melt adhesive. Laminated structures and disposable absorbent articles employing the adhesive composition would benefit from these improved characteristics. There is also a need or desire for efficient methods of making the adhesive composition, and efficient methods of making laminated structures and disposable absorbent articles employing the adhesive composition.

SUMMARY OF THE INVENTION

The present invention is generally directed to hot-melt adhesive compositions for bonding non-woven elastic composites. The adhesive compositions

have better performance characteristics, e.g. shear and peel bonding strengths, than conventional hot-melt adhesives, and may cost less than conventional hot-melt adhesives.

5 The combination of atactic polypropylene and isotactic polypropylene possesses desirable adhesive properties and may be used to make laminated elastic structures and disposable absorbent articles. The adhesive compositions of the invention can be used to bond elastic strands to various non-woven substrates, and can also be used to bond one non-woven elastic laminate to another non-woven elastic laminate under various applications. For example, the adhesive can be applied in a swirl pattern, can be melt-blown, or can be applied using any technique suitable for hot-melt adhesives.

As stated above, a material comprising a combination of atactic polypropylene and isotactic polypropylene may cost less than a conventional hot-melt adhesive. Generally this is because conventional hot-melt adhesives are typically formulated by combining several components, including a polymer or polymers for cohesive strength; resins, tackifiers, or other generally low molecular-weight materials for adhesive strength; viscosity modifiers such as oils or wax-like materials; and other additives (e.g., antioxidants). In some versions of the invention, a combination of the atactic polypropylene and isotactic polypropylene alone provides improved bond characteristics compared to conventional hot-melt adhesives. But it should be understood that the invention encompasses adhesive compositions that include selected atactic polypropylenes and isotactic polypropylenes, combined with

other additives or materials.

Another advantage present in some versions of the invention is that the material of the invention may be used in conventional hot-melt-adhesive processing equipment. Thus, the adhesive material may be used in equipment already installed
5 for the purpose of processing and applying conventional hot-melt adhesives.

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Apart from whether or not adhesive compositions of the present invention cost less than conventional hot-melt adhesives, representative embodiments of the present invention possess improved performance characteristics compared to the performance characteristics of conventional hot-melt adhesives. These performance benefits may justify processing and applying adhesive compositions of the present invention in modified conventional-hot-melt-adhesive equipment, or in equipment especially designed and built for the purpose of processing and applying adhesive compositions of the present invention. Furthermore, these performance benefits may justify adhesive compositions of the present invention, in some
15 instances, being at a higher cost than conventional-hot-melt adhesives.

These and other features, aspects, and advantages of the present invention will become better understood with regard to the following description, appended claims, and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

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Figure 1 gives symbolic representations of syndiotactic, isotactic, and atactic configurations of a polymer.

Figure 2 gives a visual representation of a fringed-micelle model of a

material having both amorphous and crystalline regions.

Figure 3 shows a schematic diagram of one version of a method and apparatus for preparing, processing, and delivering an adhesive composition.

Figure 4A shows one version of a feedback control scheme.

5 Figure 4B shows one version of a feedforward control scheme.

Figure 5 shows one version of a process control system.

Figure 6 shows one version of a process for making a laminate comprising an adhesive composition.

Figure 7A shows a top view of a portion of one version of a laminate.

Figure 7B shows a sectional, perspective view of a test panel cut from one version of a laminate.

Figure 8 shows a schematic diagram of creep testing.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

15 The present invention is generally directed to elastic attachment adhesive compositions comprising atactic polypropylene and isotactic polypropylene to make non-woven elastic composite laminates. Adhesive compositions of the present invention generally perform better, and typically cost less, than conventional
20 hot-melt adhesives. Furthermore, these compositions may typically be processed and applied using conventional hot-melt adhesive processing equipment. Generally new equipment will not be necessary to use adhesive compositions of the present invention.

Before describing representative embodiments of the invention, it is useful to define a number of terms for purposes of this application. These definitions are provided to assist the reader of this document.

5 “Non-woven” fabric or web means a web having a structure of individual fibers or threads that are interlaid, but not in a regular or identifiable manner as in a knitted fabric. Non-woven fabrics or webs have been formed from many processes such as, for example, meltblowing processes, spunbonding processes, air laying processes, and bonded carded web processes. The basis weight of non-woven fabrics is usually expressed in ounces of material per square yard (osy) or grams per square meter (gsm) and the fiber diameters are usually expressed in microns. (Note: to convert from osy to gsm, multiply osy by 33.91.)

15 “Woven” fabric or web means a fabric or web containing a structure of fibers, filaments, or yarns, which are arranged in an orderly, inter-engaged fashion. Woven fabrics typically contain inter-engaged fibers in a “warp” and “fill” direction. The warp direction corresponds to the length of the fabric while the fill direction corresponds to the width of the fabric. Woven fabrics can be made, for example, on a variety of looms including, but not limited to, shuttle looms, rapier looms, projectile looms, air jet looms, and water jet looms.

20 “Spunbonded fibers”, or “spundbond fibers”, means small-diameter fibers that are typically formed by extruding molten thermoplastic material as filaments from a plurality of fine capillaries of a spinneret having a circular or other configuration, with the diameter of the extruded filaments then being rapidly reduced

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as by, for example, in U.S. Patent 4,340,563 to Appel *et al.*, and U.S. Patent 3,692,618 to Dorschner *et al.*, U.S. Patent 3,802,817 to Matsuki *et al.*, U.S. Patents 3,338,992 and 3,341,394 to Kinney, U.S. Patent 3,502,763 to Hartman, U.S. Patent 3,502,538 to Petersen, and U.S. Patent 3,542,615 to Dobo *et al.*, each of which is
5 incorporated by reference in its entirety and in a manner consistent with the present document. Spunbond fibers are quenched and generally not tacky when they are deposited onto a collecting surface. Spunbond fibers are generally continuous and often have average diameters larger than about 7 microns, and more particularly between about 10 and 30 microns. A spunbond material, layer, or substrate comprises spunbonded (or spunbond) fibers.

The term "meltblown fibers" means fibers formed by extruding a molten material, typically thermoplastic in nature, through a plurality of fine, usually circular, die capillaries as molten threads or filaments into converging high-velocity heated gas (*e.g.*, air) streams that attenuate the filaments of molten material to reduce
15 their diameter, which may be to microfiber diameter. Thereafter, the meltblown fibers are carried by the high-velocity gas stream and are deposited on a collecting surface to form a web of randomly dispersed meltblown fibers. Such a process is disclosed for example, in U.S. Patent 3,849,241 to Butin. Meltblown fibers are microfibers which may be continuous or discontinuous, are generally smaller than 10
20 microns in diameter, and are generally self-bonding when deposited onto a collecting surface.

As used herein, the term "microfibers" means small-diameter fibers

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having an average diameter not greater than about 100 microns, for example, having a diameter of from about 0.5 microns to about 50 microns, more specifically microfibers may also have an average diameter of from about 1 micron to about 20 microns. Microfibers having an average diameter of about 3 microns or less are commonly referred to as ultra-fine microfibers. A description of an exemplary process of making ultra-fine microfibers may be found in, for example, U.S. Pat. No. 5,213,881, entitled "A Non-woven Web With Improved Barrier Properties".

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"Conventional hot-melt adhesive" means a formulation that generally comprises several components. These components typically include one or more polymers to provide cohesive strength (*e.g.*, aliphatic polyolefins such as poly (ethylene-co-propylene) copolymer; ethylene vinyl acetate copolymers; styrene-butadiene or styrene-isoprene block copolymers; *etc.*); a resin or analogous material (sometimes called a tackifier) to provide adhesive strength (*e.g.*, hydrocarbons distilled from petroleum distillates; rosins and/or rosin esters; terpenes derived, for example, from wood or citrus, *etc.*); perhaps waxes, plasticizers or other materials to modify viscosity (*i.e.*, flowability) (examples of such materials include, but are not limited to, mineral oil, polybutene, paraffin oils, ester oils, and the like); and/or other additives including, but not limited to, antioxidants or other stabilizers. A typical hot-melt adhesive formulation might contain from about 15 to about 35 weight percent cohesive strength polymer or polymers; from about 50 to about 65 weight percent resin or other tackifier or tackifiers; from more than zero to about 30 weight percent plasticizer or other viscosity modifier; and optionally less than about 1 weight percent

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stabilizer or other additive. It should be understood that other adhesive formulations comprising different weight percentages of these components are possible.

While certain versions of the present invention encompass combinations of atactic and isotactic polypropylene only, it should be understood that other embodiments of the present invention comprise components in addition to combinations of atactic and isotactic polypropylene.

“Hot-melt processable” means that an adhesive composition may be liquefied using a hot-melt tank (*i.e.*, a system in which the composition is heated so that it is substantially in liquid form) and transported via a pump (*e.g.*, a gear pump or positive-displacement pump) from the tank to the point of application proximate a substrate or other material; or to another tank, system, or unit operation (*e.g.*, a separate system, which may include an additional pump or pumps, for delivering the adhesive to the point of application). Hot-melt tanks used to substantially liquefy a hot-melt adhesive typically operate in a range from about 100 degrees Fahrenheit to about 450 degrees Fahrenheit. Generally, at the point of application, the substantially liquefied adhesive composition will pass through a nozzle or bank of nozzles, but may pass through some other mechanical element such as a slot. A hot-melt processable adhesive composition is to be contrasted with a composition that requires a conventional extruder, and the attendant pressures and temperatures characteristic of an extruder, to liquefy, mix, and/or convey the composition. While a hot-melt tank and pump in a hot-melt processing system can handle adhesive-composition viscosities in a range of up to 50,000 centipoise, an extruder can handle and process

adhesive-composition viscosities in a range from about 10,000 centipoise to viscosities of several hundred thousand centipoise. An advantage of some adhesive compositions of the present invention is that the compositions are hot-melt processable; *i.e.*, the combination of atactic and isotactic polypropylene may be substantially liquefied in a hot-melt tank and conveyed to the point of application via a pump. As was stated above, however, some adhesive compositions of the present invention may not possess this particular advantage.

Unless otherwise noted, "laminated structure" or "laminate" means a structure in which one layer, material, component, web, or substrate is adhesively bonded, at least in part, to another layer, material, component, web, or substrate. As stated elsewhere in this application, a layer, material, component, web, or substrate may be folded over and adhesively bonded to itself to form a "laminated structure" or "laminate."

"Elastic," "elastomeric," "elasticized," and "elasticity" mean that property of a material or composite by virtue of which it tends to recover its original size and shape after removal of a force causing a deformation. An elastic, or elastomeric, material or composite is one that can be elongated by at least 25 percent of its relaxed length and will recover, upon release of the applied force, at least 10 percent of its elongation. It is generally preferred that the elastomeric material or composite be capable of being elongated by at least 100 percent, more preferably by at least 300 percent, of its relaxed length and recover, upon release of an applied force, at least 50 percent of its elongation.

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“Polymer”, as used herein, generally includes, but is not limited to, homopolymers, copolymers, such as, for example, block, graft, random and alternating copolymers, terpolymers, and blends and modifications thereof. As is explained in this document, polymers may assume different configurations, including isotactic, atactic, and syndiotactic configurations. “Configuration” describes those arrangements of atoms that cannot be altered except by breaking and reforming primary chemical bonds (*i.e.*, covalent bonds). In contrast, “conformation” describes arrangements that can be altered by rotating groups of atoms around single bonds. It should be noted that a single polymer chain may be synthesized such that some portions of the chain have an isotactic configuration and some portions of the chain have an atactic configuration.

A graphic example provides additional detail on the types of configurations mentioned above. If a polymer chain is depicted in a fully-extended, planar, zigzag conformation, the configuration resulting when all the substituent groups R lie on the polymer lie above (depicted in Figure 1B) or below (not depicted) the plane of the main chain is called “isotactic”. If substituent groups lie alternately above and below the plane the configuration is called “syndiotactic” (depicted in Figure 1A). And a random sequence of substituents lying above and below the plane is described as an “atactic” configuration (depicted in Figure 1C). A polymer, or a region of a polymer, having an isotactic configuration is more likely to assume characteristics of a crystalline structure. For purposes of this invention, the term “isotactic polymer” refers to a polymer that is at least 60% isotactic, suitably at

least 70% isotactic, alternatively at least 80% isotactic. A polymer, or a region of a polymer, having an atactic configuration is more likely to assume characteristics of an amorphous structure. An atactic polymer may assume some crystallinity, but the degree of crystallinity is typically less than 20%, or less than 15%. For purposes of this invention, the term "atactic polymer" refers to a polymer that may not be 100% atactic, but is at least 80% atactic. And a polymer, or a region of a polymer, having a syndiotactic configuration can assume characteristics of a crystalline structure, which is similar to the degree of crystallinity in an isotactic configuration.

In this application, "fringed-micelle model" means a theoretical construct characterizing polymeric structures that have both crystalline and amorphous regions (one version of a graphic depiction of a fringed-micellar structure is presented in Figure 2). This model may be used to characterize the structure of an atactic polymer and an isotactic polymer individually, i.e., each polymer possesses both crystalline regions and amorphous regions. As explained above, the isotactic polymer likely possesses a greater degree of crystallinity compared to an atactic polymer. Furthermore, this model may be used to characterize the structure of a blend of isotactic polymer and atactic polymer. It should be understood that this model provides one possible view of characteristics of the present invention and in no way limits the scope thereof.

One version of an adhesive composition possessing features of the present invention comprises an atactic polypropylene having a degree of crystallinity of about 20% or less, specifically a crystallinity of about 15% or less, a number-

average molecular weight of from about 500 to about 40,000, specifically about 1,000 to about 30,000, and a molecular weight distribution index in a range of 2 to 10. The composition also includes an isotactic polypropylene having a degree of crystallinity of about 40% or more, specifically of about 60% or more, particularly of about 80% or more, a number-average molecular weight of from about 3,000 to about 150,000, more particularly of about 5,000 to about 100,000, and a molecular weight distribution index in a range of 2 to 8. The adhesive composition is hot-melt processable at a temperature of about 450 degrees Fahrenheit or less, specifically in a range of about 350 to about 400 degrees Fahrenheit.

This adhesive composition can have a melt index between about 100 and about 2000 grams per 10 minutes, or between about 200 and about 1800 grams per 10 minutes, or between about 500 and about 1500 grams per 10 minutes, as determined using ASTM D 1238, 230°C Method. The melt index is dependent upon the crystallinity, molecular weight, and the molecular weight distribution of the polymers included in the adhesive composition.

In some versions of the invention, the atactic polypropylene is present in an amount of about 50 to about 90 weight percent and the isotactic polypropylene is present in an amount of about 5 to about 50 weight percent. For purposes of this invention, weight percent is defined as the mass of one type of polymer (e.g., atactic polypropylene) in the adhesive composition divided by the sum of the masses of other types of polymer (e.g., atactic polypropylene and isotactic polypropylene) in the adhesive composition, plus the mass(es) of any additional component(s) that might

be present in the adhesive composition, with this value being multiplied by 100. So, for example, if we form an adhesive composition comprising 80 grams of atactic polypropylene with 20 grams of isotactic polypropylene, the combination includes 80 weight percent atactic polypropylene.

5 In another aspect, the invention encompasses elastic composite laminated structures employing embodiments of the adhesive composition as described above. For example, one version of a laminated structure of the present invention comprises a first elastic layer and a second layer that may or may not be elastomeric, wherein at least a portion of the first layer is attached to at least a portion of the second layer using an adhesive composition that is the same as, or analogous to, one or more of the embodiments described above, and wherein the laminated structure has improved dynamic peel strength, improved dynamic shear strength, and improved static-peel-failure time, relative to conventional hot-melt adhesive compositions. The adhesive composition itself is stretchable, thus providing added stretchability to laminates of the invention.

For any of the laminated structures described above, the first and second layer may be part of one-and-the-same substrate. That is, the substrate may be folded over and joined to itself using an adhesive composition of the present invention. One or both layers may suitably be stretched between about 25% and about 300%, or between about 70% and about 200%, or between about 100% and about 150%.

Furthermore, the first layer, second layer, or both may comprise a variety of materials, including, but not limited to non-woven materials (e.g., necked-

Patent Number 5,336,545 to Morman, entitled "Composite Elastic Necked-Bonded Material," which is hereby incorporated by reference in its entirety in a manner consistent with the present document. A spunbond-meltblown-spunbond ("SMS") laminate may generally comprise a plurality of meltblown fibers sandwiched between two polypropylene spunbonded layers. For additional detail on how SMS laminates are formed, see U.S. Patent Number 4,041,203 to Brock et al., which is hereby incorporated by reference.

As yet another example, the adhesive composition can be used to bond one non-woven elastic laminate to another non-woven elastic laminate, such as an NBL to an NBL, or an NBL to a stretch-bonded laminate, or an NBL to a polypropylene spunbonded layer, or a stretch-bonded laminate to a stretch-bonded laminate, or a stretch-bonded laminate to a spunbonded layer, or a spunbonded layer to a spunbonded layer. A stretch-bonded laminate ("SBL") is generally a laminate made up of an elongated elastic web or elongated elastomeric strands bonded between two spunbond layers, for example. An SBL is typically stretchable in the machine-direction by at least 50%, suitably at least 150%, or at least 300%. For additional detail on how SBLs are formed, see European Patent Application No. EP 0 217 032 published on April 8, 1987 in the names of Taylor et al., which is hereby incorporated by reference in its entirety in a manner consistent with the present document.

In yet another aspect, an absorbent article may be formed that employs an adhesive composition of the present invention and/or a laminated structure of the present invention. So, for example, one version of an absorbent article of the present

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invention comprises a liquid-permeable topsheet; a liquid-impermeable backsheet;
and a laminated structure having features of the present invention, such as one or
more of the versions described above. Some or all of the backsheet may include the
laminated structure; some or all of the topsheet may include the laminated structure;
5 the laminated structure may be attached, directly or indirectly, to the backsheet, the
topsheet, or both; or a laminated structure or structures may be present in some
combination of these.

In addition to various versions of adhesive compositions, laminated
structures, and absorbent products of the present invention, the present invention also
encompasses methods of making these compositions, structures, and articles of
manufacture.

One version of a method of making a laminated structure having features
of the present invention comprises the steps of providing a first substrate and a second
substrate, with at least one of the substrates being elastomeric. Also provided is an
15 atactic polypropylene having a degree of crystallinity of about 20% or less, suitably
about 15% or less, and a number-average molecular weight of from about 500 to
about 40,000, specifically about 1,000 to about 30,000; and an isotactic
polypropylene having a degree of crystallinity of about 40% or more, specifically of
about 60% or more, particularly of about 80% or more, and a number-average
20 molecular weight of from about 3,000 to about 150,000, more particularly of about
5,000 to about 100,000.

The atactic polypropylene and isotactic polypropylene are heated so that

they are sufficiently liquefied for blending. The heated atactic polypropylene and the heated isotactic polypropylene are blended to form an adhesive composition that is melt-processable at a temperature of less than about 450 degrees Fahrenheit, specifically in a range of about 350 to about 400 degrees Fahrenheit. The adhesive composition is applied to the first substrate, the second substrate, or both substrates. At least a portion of the first substrate is joined to at least a portion of the second substrate so that some or all of the applied adhesive composition is positioned between the first substrate and second substrate.

In some methods of the present invention, the atactic polypropylene is present in an amount of about 50 to about 90 weight percent and the isotactic polypropylene is present in an amount of about 5 to about 50 weight percent.

It should be understood that the atactic polypropylene and isotactic polypropylene could be heated and blended at a site other than the site where the laminate is being formed. For example, atactic and isotactic polypropylene could be blended using an extruder or hot-melt processing equipment at a first geographic location. The blend could then be allowed to cool and processed to make a solid form (e.g., pellets). The atactic/isotactic polypropylene blend, in solid form, could then be shipped from the first geographic site to a site where a laminate is to be made. The blend, in solid form, would simply be heated to substantially liquefy the adhesive composition prior to its being used to make a laminate.

It should also be understood that a method having features of the present invention encompasses different sequences of steps by which the adhesive

composition is made. For example, the atactic polypropylene could be heated in a first container. The isotactic polypropylene could be heated in a second container, before, after, or concurrently with the heating of the atactic polypropylene. Then, the two substantially liquefied polymers could be blended in the first container, the second container, or a third container. Alternatively, one of an atactic or isotactic polypropylene could be heated in a container, and after the selected polymer is substantially liquefied, the remaining polymer could be added to the same container to be heated and blended. In another alternative, the atactic and isotactic polypropylene could be added to the same container to be heated and blended at the same time. In other words, the invention contemplates various methods and sequences by which selected amounts of atactic and isotactic polypropylene (plus any other optional additives) are heated and blended to form an adhesive composition of the present invention.

The preceding discussion assumes that the atactic and isotactic polypropylene are in substantially solid form at room temperature, or temperatures that are typically present in a working environment suitable for human beings. To the extent that the atactic or isotactic polypropylene is available in substantially liquid form, then those steps providing for heating and liquefying that material (*i.e.*, the already-liquefied material) can be omitted from methods of the present invention.

One version of a method in which an adhesive composition of the present invention is metered or delivered at a desired rate to a unit operation (*e.g.*, a unit operation where the adhesive composition is applied to a substrate or substrates

in order to make a laminate) comprises the steps of: determining the amount of adhesive composition being used by the unit operation per unit time; and force-adjusting the volumetric flow rate or the mass flow rate of the adhesive composition so that the amount of adhesive composition being metered or delivered to the unit operation corresponds to the amount of adhesive composition being used by the unit operation per unit time.

In the process description that follows, the preparation, processing, and application of an adhesive composition including atactic and isotactic polypropylene is described. It should be understood, however, that this description is given as an example. Other processing methods and equipment may be used to prepare and deliver various adhesive compositions of the present invention.

Figure 3 shows a schematic diagram of an apparatus 20, and a method for spraying an adhesive composition, on a moving web 22. The apparatus 20 may include a programmable control system 24 that is operatively connected to a flow-control system 26. The combination of the programmable control system 24 and the flow-control system 26 are configured to control the delivery of an adhesive composition in liquid form to the moving web 22.

Generally, an adhesive composition is received in solid form at a manufacturing site where equipment such as that depicted in Figure 3 is located. For example, hot-melt adhesive compositions may be received as solid pellets, blocks, or some other shape. The solid is then heated so that the hot-melt adhesive composition is in a form such that it can be conveyed, and applied, to a substrate or other material.

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Usually this requires that the heated hot-melt adhesive be in substantially liquid form. For the present invention, an adhesive composition comprising atactic polypropylene and isotactic polypropylene in solid form might be received at a manufacturing site for heating and processing as described above. Alternatively, the atactic polypropylene and isotactic polypropylene might be received as separate components to be blended at the manufacturing site. As discussed above, the present invention encompasses a variety of sequences of steps for making adhesive compositions of the present invention. An example of equipment and methods for heating an adhesive composition, or precursor materials to the adhesive composition, are described in more detail below.

The apparatus may also include a position-sensing system that is configured to sense a position of the moving web 22 and, in response thereto, generate a signal that is sent to the programmable control system 24.

As representatively illustrated in Figure 3, the continuously moving web 22 may be supplied by any means known to those skilled in the art, such as known conveyor systems. The continuously moving web 22 can include any type of layer or web of material, such as films, non-woven webs, woven webs which may include strands of thermoplastic material; elastomeric components; natural material such as threads of cotton and the like; laminate materials; or combinations thereof. More particularly, the continuously moving web 22 may include a necked-bonded laminate, which generally comprises a polyethylene layer sandwiched between two polypropylene, spunbonded layers; a polypropylene, spunbonded layer; or an

outercover comprising a polyethylene layer and a polypropylene, spunbonded layer.

As is described below in more specific terms, the adhesive is sprayed on the continuously moving web 22 in a specific design or pattern for subsequent placement of or bonding to another material. The other material can be the same or different than the web to which adhesive was applied, as long as at least one of the substrates is elastomeric. In some cases adhesive might be applied to both substrates before they are joined together. And, as mentioned above, one substrate might be folded over and attached to itself to form a laminated structure.

The programmable control system 24 of the present invention is configured to send signals to the flow control system 26 which, in response thereto, is configured to initiate a spray of adhesive at the correct time to provide the desired pattern of adhesive on the moving web 22. As representatively illustrated in Figure 3, the flow control system 26 includes an adhesive source 28 which is configured to deliver an adhesive through an adhesive supply line 30 to a metering mechanism 32. The adhesive can be delivered to the metering mechanism 32 by any means known to those skilled in the art, such as by the use of a pump.

The metering mechanism 32 is configured to continuously supply at least one independent, volumetric flow of adhesive to a respective nozzle. As used herein, the term "volumetric flow" refers to a flow of adhesive that has a predetermined volumetric flow rate. Such a "volumetric flow" may be provided by a positive-displacement metering pump which is configured to supply a specific volumetric flow which is independent of the manner in which the adhesive is supplied

be controlled to vary the volumetric flow rate of adhesive to the nozzles.

Each nozzle 38 and 40 as representatively illustrated in Figure 3 can be any device which is capable of providing the desired pattern of adhesive on the moving web 22. For example, one suitable nozzle is commercially available from
5 Nordson Corporation, a business having offices located in Duluth, Ga., under the trade designation Model No. 144906. Another suitable nozzle for use in the present invention is obtainable from ITW Dynatec Co. of Hendersonville, Tenn., under the trade designation number 057B1639, I.D. #A3. Such nozzles are typically configured to be operated between an on position and an off position to control the spray of adhesive from the nozzles. When operated in the on position, each nozzle may be configured to spray substantially the entire volumetric flow of adhesive which is independently supplied to it to more accurately control the amount and pattern of the adhesive on the moving web. The nozzles 38 and 40 may further be configured to include air streams that can be directed to provide a desired pattern in the spray of
15 adhesive being dispensed from each nozzle. Such air streams can provide a desired adhesive spray pattern, such as a pattern of swirls of adhesive.

After the pattern of adhesive has been sprayed on the moving web 22, the web may be further processed in a variety of ways. For example, the continuously moving web 22 may be contacted by a second substrate web, such as
20 a non-woven layer, between a pair of nip rolls to adhesively join the two substrate webs together. Thereafter, this composite material or laminate may be used in a variety of ways such as in the construction of disposable absorbent articles such as

diapers, incontinent articles, training pants, feminine care articles and the like.

The above discussion provides one example of hot-melt processing equipment 15 and a system for applying adhesive to a substrate. It should be understood that this is but one example, and that the present invention encompasses other systems for preparing and applying adhesives (*see, e.g.*, U.S. Patent No. 4,949,668, entitled "Apparatus for Sprayed Adhesive Diaper Construction," which issued on 21 August 1990, and which is hereby incorporated by reference in its entirety and in a manner consistent with the present document).

Regardless of the system used to apply the adhesive, the resulting composite material or laminate may be exposed to thermal, infrared, ultrasonic, or other forms of energy in subsequent unit operations or processing steps. For example, the laminate or composite material may pass through an ultrasonic-bonding unit operation wherein the laminate or composite material are exposed to ultrasonic energy. After exemplary composite materials or laminates such as those referred to above are formed using an adhesive composition of the present invention, some or all of the composite or laminate may be exposed to ultrasonic energy. Referring to PCT International Publication Number WO 99/25296, which is hereby incorporated by reference in its entirety in a manner consistent with the present document, the publication discloses the use of ultrasonic bonding to form side seams or seals in the disposable underpant. (*See, e.g.*, page 29, lines 10-25; additional detail regarding the forming of such side seals is disclosed in U.S. Patent Number 4,610,681, which issued on 09 September 1986 and is entitled "Disposable Underpants Having Discrete

Outer Seals,” and which is hereby incorporated by reference in a manner consistent herewith; and U.S. Patent Number 4,641 ,381, which issued on 10 February 1997 and is entitled “Disposable Underpants, Such as Infant’s Training Pants and the Like,” which is also incorporated by reference in a manner consistent with the present document.)

Thus, adhesives of the present invention, used to make laminates and composite materials, may be exposed to ultrasonic energy when ultrasonic-bonding equipment is used in subsequent processing steps (*e.g.*, when the ultrasonic bonding equipment is used to form the seams or seals in the disposable absorbent article as discussed above).

Specific examples of composite materials, laminates, and disposable absorbent articles with which adhesives of the present invention may be utilized are disclosed in the following U.S. Patents and U.S. Patent Applications: U.S. Patent No. 4,798,603 issued Jan. 17, 1989, to Meyer *et al.*; U.S. Patent No. 5,176,668 issued Jan. 5, 1993, to Bernardin; U.S. Patent No. 5,176,672 issued Jan. 5, 1993, to Bruemmer *et al.*; U.S. Patent No. 5,192,606 issued Mar. 9, 1993, to Proxmire *et al.*; U.S. Patent No. 4,940,464, entitled “Disposable Incontinence Garment or Training Pant”; U.S. Patent No. 5,904,675, entitled “Absorbent Article With Improved Elastic Margins and Containment System”; U.S. Patent No. 5,904,672, entitled “Absorbent Article Having Improved Waist Region Dryness and Method of Manufacture”; and U.S. Patent No. 5,902,297, entitled “Absorbent Article Having a Collection Conduit.” Each of the preceding U.S. patents is incorporated by reference in its entirety and in

a manner consistent with the present document. More specifically, the types of absorbent articles in which the adhesives of the present invention may be used include diapers, children's training pants, swim wear, incontinence products, feminine care products, other personal care or health care garments, including medical garments, or the like. It should be understood that the present invention is applicable to other structures, composites, or products incorporating adhesive compositions of the present invention.

Additional Detail on Representative Process-Control Embodiments

As discussed above, process-control systems may be used to control the volumetric or mass flow rate of adhesive compositions of the present invention to a point of application (e.g., to a point of application on a substrate, layer, or web that will be used to make a laminate or composite material). Persons of ordinary skill in the art of process control are familiar with the various process-control strategies, algorithms, and equipment used to control a process. Some of the possible strategies that may be used to control a process include feedback-control strategies (*i.e.*, a process in which a variable to be controlled is measured, the measured value is compared to a desired value, and the difference between the measured value and the desired value is transmitted to a feedback controller that force adjusts a manipulative variable to drive the measured variable back to the desired value) (*see, e.g.*, Figure 4A); feedforward-control strategies (*i.e.*, a process in which a disturbance entering a process is detected, and an appropriate change is made to a manipulative variable so that an output variable is held constant; *see, e.g.*, Figure 4B); and the like.

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One example of a process-control system is depicted in Figure 5. A sensor may be used to determine a signal S_1 corresponding to the variable to be controlled, *e.g.* the volumetric or mass flow rate of adhesive being sprayed or delivered in an adhesive-application unit operation 74. This signal may then be relayed electrically, pneumatically, hydraulically, or by other means to a transmitter 76, which converts the signal S_1 into a control signal M_1 . The transmitter transmits the control signal M_1 to the controller 78.

After receiving the control signal M_1 , the controller sends the corresponding output signal R_1 to the control element 80. The control element, such as an electronic or pneumatic control valve, responds to the output signal R_1 by opening or closing, thus effecting the desired change to the variable being manipulated, in this case the volumetric or mass flow rate of adhesive. Alternatively, the control element might effect a desired change to the speed at which a pump operates, thereby controlling the mass or volumetric flow rate of adhesive.

As mentioned above, an air-pressure, electrical, pneumatic, or other signal may be used to transmit information (*e.g.*, the various signals discussed in the preceding paragraphs) from one device to another (*e.g.*, from a sensor, to a transmitter, to a controller, to a control element, or to some combination of some or all of these). For example, the controller may be a device that converts a control signal into an equivalent air-pressure, electrical, pneumatic, or other output signal. This air-pressure, electrical, pneumatic or other output signal is sent from the controller to a control element that effects a change to the variable being manipulated.

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If the output signal is an air-pressure signal, the output signal will be transmitted to the control element via tubing. The control element, such as a pneumatic control valve, responds to the output signal by opening or closing, thus effecting the desired change to the variable being manipulated. The control system may include multiple valves: *e.g.*, a two-valve system with one operating as a one-directional, open-or-shut valve and the other operating as a proportional valve. Alternatively, the output signal is converted into an electrical signal. The output signal is relayed to the control element via metal wire or other electrical conductor. The control element, such as an electronic control valve, responds to the electrical signal by opening or closing, thus effecting the desired change to the variable being manipulated.

15
An operator may input a value directly to the controller to produce a control signal. For example, an operator may adjust a dial or other input device on a pneumatic, hydraulic, electronic, or other controller to adjust the volumetric or mass flow rate of adhesive. The operator selects a setting on the input device of the controller corresponding to the flow rate desired by the operator. Typically the operator will have calibrated the input device on the controller so that input-device settings each correspond to specific volumetric or mass flow rate values.

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A general-purpose computer may be used in place of, or in addition to, the controller mentioned above. Typically a general-purpose computer employs an input device, including, but not limited to, an alpha-numeric keyboard, mouse, joystick, stylus, touch screen, or some combination of these. Other devices which may be used to input data to the computer include, but are not limited to: devices for

reading data stored on magnetic media such as 3.5 inch "floppy disks" or fixed-
drives; devices for reading data stored on optical media, such as CD-ROMs; devices
for reading data transmitted over cables, including optical cables; and devices for
scanning and digitizing information on a document. In addition to the input devices
5 like those mentioned above, a general-purpose computer usually includes a visual
display for displaying data. Also, a general-purpose computer typically has a device
for storing and retrieving data that is inputted to the computer. Devices for storing
and retrieving data include, but are not limited to: a disk drive for reading data from,
and storing data on, a 3.5 inch "floppy disk"; a hard disk or other fixed drive; a tape
drive; or other device capable of reading data from, and storing data on, magnetic
media.

A general-purpose computer may be adapted for use in controlling the
volumetric or mass flow rate of adhesive. Typically a general-purpose computer
comprises devices for data input, data storage, data processing, data display, and data
15 output, as discussed above. For purposes of controlling volumetric or mass flow rate,
the general-purpose computer may further comprise a set of instructions comprising
the following steps: reading the control signal M_1 , the control signal M_1 being
transmitted to the computer in computer-readable form; correlating the control signal
 M_1 to an output signal R_1 and transmitting the output signal R_1 to a control element.
20 The control element, such as an electronic, hydraulic, pneumatic, or other control
valve, responds to the output signal R_1 by opening or closing, thus effecting the
desired change to the variable being manipulated, in this volumetric or mass flow

rate. Alternatively, the control element may effect desired changes to the speed at which a positive-displacement or other metering pump operates, thereby effecting desired changes to mass or volumetric flow rates.

The above discussion provides exemplars of equipment and methods for controlling the amount of adhesive being conducted to a point of application per unit time. It should be understood that other equipment and methods used to force adjust the flow rate of an adhesive of the present invention to a control set point, operator-inputted value, or other desired value falls within the scope of the present invention.

TESTS / PROCEDURES

Laminate Production

Laminates were made on equipment available from J & M Laboratories, a business having offices located in Dawsonville, Georgia. As depicted in Figure 6, a first substrate or first base material 102, such as a non-woven web, was directed from its corresponding unwind stand (not shown) to the surface of a 6-inch-diameter steel roll 104 and through a nip 106 between the steel roll and a 4-inch-diameter rubber roll 110. A second substrate or second base material, such as a second non-woven web 108, was directed from its unwind stand (not shown) to the surface of the rubber roll and through the nip. Typically, the equipment was operated at a speed of 300 feet per minute.

The applicator 114 used to deposit the adhesive was positioned so that the face of the depicted nozzle, which was roughly parallel to the surface of the web to which adhesive was first applied, was 1.5 inches 116 from the surface of the web.

Furthermore, the central axis of the depicted nozzle, which is perpendicular to the web to which adhesive is first applied, was 8 inches 118 from a parallel axis that passes through the nip defined by the rubber and steel rolls.

From the discussion above, it should be understood that the substrates and the resulting laminate 700 generally moved in a machine direction 702 (see Figure 7A) during their preparation. Figure 7A depicts a top view of a portion of a laminate after it has been formed. A continuous band of adhesive 703, whether it was applied using meltblowing, cycloidal, slot, or other application technique, is denoted by broken lines 705 and 707. The adhesive is under the upper substrate of the laminate depicted in the Figure. As the laminate is made in a continuous manner, it is wound up in the form of a roll. The direction that is perpendicular to the machine direction, but lying within the plane of the laminate, is denoted as the cross-machine direction 704. Typically the width of the formed laminate, width denoting the dimension parallel to the cross-machine direction, was about 1 to about 12 inches 706. The width of the applied adhesive, again width denoting a dimension parallel to the cross-machine direction, typically was from about 0.5 inch to about 10 inches 708. Also, the band of adhesive was generally applied such that it was substantially centered in the laminate (in the width dimension). Unless otherwise noted, the width of the applied adhesive was about 0.5 inch to about 2 inches. (Note: the lines 710 and 712 denote the manner in which a 2-inch 714 sample was cut for subsequent analysis; sample preparation and orientation is discussed in more detail below).

The selected adhesive was either an adhesive of the present invention

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(as noted in the Examples below), or a hot-melt adhesive (again as noted in the Examples below). The adhesive was added using a variety of patterns, including a meltblown pattern, a swirl or cycloidal pattern, or a pattern resulting from slot coating. Typically the adhesives were heated to temperatures ranging from about 350
5 degrees Fahrenheit to about 380 degrees Fahrenheit prior to application to one of the substrates. Unless otherwise noted, the selected adhesive was added using a meltblown pattern. As stated above, unless otherwise noted the width of the added adhesive was about 0.5 inch to about 2 inches. The selected adhesive was added in amounts varying from about 1 gram per square meter to about 50 grams per square
10 meter, with specific application levels or add-on levels noted in the examples.

A number of different substrates were used to prepare the laminates, as noted in the Examples below. The substrates that were used included: a necked-bonded laminate ("NBL"), which generally comprised a polyethylene layer sandwiched between two polypropylene, spunbonded layers; a polypropylene, spunbonded layer ("SB"); and a spunbond-meltblown-spunbond layer ("SMS")
15 generally comprising a layer of meltblown fibers sandwiched between two polypropylene, spunbonded layers. For tests where the performance of a laminate of the present invention was compared to the performance of a laminate prepared using a conventional hot-melt adhesive, the same substrates were used to prepare both the
20 laminate of the present invention and the conventional laminate.

180° Static Peel Test

The static peel test was used to determine the approximate time to failure

of a laminate in which one substrate was adhesively bonded to another substrate. All laminates were made as described above on a J & M machine. Samples were cut from the prepared laminate which was in the form of a continuous web prepared on a J & M machine, as shown in Figure 7A. Figure 7B depicts a sectional view of a sample that has been removed from the laminate depicted in Figure 7A.

The test procedure was conducted as follows: 1. A 2-inch test panel was cut from the laminate, as shown in Figures 7A and 7B. 2. The test laminate was then suspended vertically in a forced-air oven, model number OV-490A-2 manufactured by Blue M Co., a business having offices in Blue Island, Illinois, that had been preheated to a temperature of 100 degrees Fahrenheit, with the top of one substrate layer 750 secured by a clamp or other mechanical securing element, the clamp or securing element having a width of about 2 inches. 3. A 500-gram weight was then affixed to the top edge 752 of the other substrate using a clamp or other mechanical securing element. Again, the clamp or securing element used to attach the 500-gram weight was about 2 inches. 4. Approximately every ½ hour, the test laminate was visually examined by quickly opening the oven door. The time at which one substrate or layer had detached from the other substrate or layer was recorded. The recorded time corresponded to the approximate time of failure of the laminate.

The two, now separate, substrates were then examined to determine the nature of the failure. If the substrates separated such that most of the adhesive remained on one of the substrates, then failure was deemed to be an adhesion failure (*i.e.*, failure likely occurred at the interface between one of the substrates and the

adhesive composition). If the substrates separated such that adhesive remained on both substrates, the failure was deemed to be a cohesion failure (*i.e.*, separation likely occurred within the adhesive composition itself). If neither of these conditions arose, but instead one or both of the substrates failed (*i.e.*, that portion of the laminate bonded by the adhesive, usually a 1 inch by 2 inch area of the test panel), then the failure was deemed a material failure of one or both substrates.

Dynamic Peel and Shear Testing

To determine dynamic peel strength, a laminate was tested for the maximum amount of tensile force that was needed to pull apart the layers of the laminate. Values for peel strength were obtained using a specified width of laminate (for the present application, 2 inches); clamp jaw width (for the present application, a width greater than 2 inches); and a constant rate of extension (for the present application, a rate of extension of 300 millimeters per minute). For samples having a film side, the film side of the specimen is covered with masking tape, or some other suitable material, in order to prevent the film from ripping apart during the test. The masking tape is on only one side of the laminate and so does not contribute to the peel strength of the sample. This test uses two clamps, each clamp having two jaws with each jaw having a facing in contact with the sample, to hold the material in the same plane, usually vertically. The sample size is 2 inches (10.2 cm) wide by 4 inches (20.4 cm). The jaw facing size is 0.5 inch (1.25 cm) high by at least 2 inches (10.2 cm) wide, and the constant rate of extension is 300 mm/min. For a dynamic peel test, one clamp is attached to the top 750 of one substrate of a test panel (*see* Figure 7B).

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The other clamp is attached to the top 752 of the other substrate of a test panel. During testing, the clamps move apart at the specified rate of extension to pull apart the laminate. The sample specimen is pulled apart at 180 degrees angle of separation between the two layers, and the peel strength reported is the maximum tensile strength, in grams, recorded during the test. Each of the peel strengths reported below is an average of five to nine tests. A suitable device for determining the peel strength testing is a SINTECH 2 tester, available from the Sintech Corporation, a business having offices at 1001 Sheldon Dr., Cary, N.C. 27513; or an INSTRON Model TM, available from the Instron Corporation, a business having offices at 2500 Washington St., Canton, Mass. 02021; or the Thwing-Albert Model INTELLECTII available from the Thwing-Albert Instrument Co., a business having offices at 10960 Dutton Rd., Philadelphia, Pa. 19154.

For a dynamic shear test, the procedure is as described above except that one clamp is attached to the top 750 of one substrate of the laminate, and the other clamp is attached to the bottom 754 of the other substrate of the laminate. The shear strength reported is the maximum tensile strength, in grams, recorded during the test. Each of the shear strengths reported is an average of five to nine tests.

Thermal Stability: Thermogravimetric Analysis

The thermal stability of versions of adhesive compositions of the present invention was determined using thermogravimetric analysis. For the thermogravimetric analysis, a sample of adhesive was placed in a sample holder in the heating element of a Model 951 Thermogravimetric Analyzer made by TA

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Instruments, a business having offices in New Castle, Delaware. The sample was heated from room temperature, which was approximately 21 °C, to a temperature of 450 °C at a heating rate of 10 °C per minute. The sample was heated under a dynamic atmosphere of air with a flow of approximately 80 milliliters per minute. The crucible was continuously weighed during heating so that any decrease in weight could be detected. The resulting weight-change curves for the tested adhesives, *i.e.* plots of sample weight versus temperature, showed that blends of atactic and isotactic polypropylene (with the blends typically ranging from about 10 weight percent to about 30 weight percent isotactic polypropylene) generally experienced no weight loss until reaching a temperature of about 235 °C in air. The desirable thermal stability of the atactic and isotactic polypropylene blend is attributed to the saturated chemical bond nature of the blend, which is critical for use as a hot-melt adhesive.

Viscosity

Atactic and isotactic polypropylene blends of varying compositions were formulated into 10.0 g samples. These samples were heated to or above 400 °F in a Brookfield Digital Rheometer Model DV-III using a Brookfield Temperature Controller (available from Brookfield Engineering Laboratories, a business having offices in Stoughton, MA). Spindle #27 was used for all trials and the instrument was appropriately zeroed and calibrated before each test. After the sample had been stabilized and sufficiently mixed at 400 degrees Fahrenheit (or above), readings of the spindle rpm, torque, and viscosity were recorded. The temperature was then lowered, typically in 10 °F increments, and the sample allowed to stabilize for 10-15

minutes before subsequent readings of spindle rpm, torque, and viscosity were taken.

For various blends of isotactic polypropylene and atactic polypropylene (*see* Example 1 below for characteristics), Brookfield viscosities at 360 degrees Fahrenheit were: for 10 weight percent isotactic polypropylene/90 weight percent atactic polypropylene, the viscosity was 3200 centipoise; for 20 weight percent isotactic polypropylene/80 weight percent atactic polypropylene, the viscosity was 4700 centipoise; for 30 weight percent isotactic polypropylene/70 weight percent atactic polypropylene, the viscosity was 6300 centipoise; and for 40 weight percent isotactic polypropylene/60 weight percent atactic polypropylene, the viscosity was 7000 centipoise.

For various blends of isotactic polypropylene and atactic polypropylene (*see* Example 1 below for characteristics), Brookfield viscosities at 380 degrees Fahrenheit were: for 10 weight percent isotactic polypropylene/90 weight percent atactic polypropylene, the viscosity was 2500 centipoise; for 20 weight percent isotactic polypropylene/80 weight percent atactic polypropylene, the viscosity was 3600 centipoise; for 30 weight percent isotactic polypropylene/70 weight percent atactic polypropylene, the viscosity was 4900 centipoise; and for 40 weight percent isotactic polypropylene/60 weight percent atactic polypropylene, the viscosity was 5300 centipoise.

Molecular Weight (Number Average and Weight Average)

Atactic polypropylene, isotactic polypropylene, and blends of atactic and isotactic polypropylene were sent to American Polymer Standard Corp., a business

having offices in Philadelphia, PA, for molecular-weight determinations. The number-average and/or weight-average molecular weights were determined by American Polymer using gel-permeation chromatography on a Waters Model No. 150 gel-permeation chromatograph. The determinations were made using: four, linear, Shodex GPC gel columns; poly(styrene-divinyl benzene) copolymers as standards; trichlorobenzene as the solvent, introduced to the chromatograph at a volumetric flow rate of 1.0 milliliter per minute; an operating temperature of 135 degrees Celsius; a sample-injection volume of 100 microliters; an M-150C-(64/25) detector; and a GPC PRO 3.13 IBM AT data module.

Thermal Aging Process

A 200-gram sample of each hot melt adhesive was put in a 1 pint Mason jar and covered with aluminum foil and sealed. The jar was then placed in an oven at 350° Fahrenheit for 72 hours (for construction adhesives) or 96 hours (for elastic attachment adhesives).

Creeping Resistance of Elastic Strands

Twelve elastic strands 302, approximately 2.5 mm apart in the cross-direction and each elongated approximately 300%, were adhesively attached and sandwiched between two 4-inch wide continuous polypropylene spunbonded layers 304 to form a laminate. The laminate was fully extended by hanging a weight (about 500 grams or higher) at one end of the laminate, and a 200 mm machine-direction length was then marked. The laminate was then released, such that the 200 mm length snapped back to 175 mm, whereupon the 175 mm length was marked. The

lamine was then stapled to a piece of cardboard at the 175 mm length. The marked length of the lamine was then cut to release tension in the elastic strands 302, and the snapback length of the strands was measured. An illustration of the creeping test procedure is shown in Figure 8.

5 Initial creep percentage was calculated by first determining the difference between the 175 mm length and the snapback length, then dividing the difference by the 175 mm length and multiplying the quotient by 100, as shown in the following equation:

$$\text{Initial Creep \%} = (175_{\text{mm}} - X_{\text{initial creep}}) / 175 \times 100$$

10 The sample was then placed in an oven at 100° Fahrenheit for 90 minutes to measure aging creep. Aging creep percentage was then calculated by determining the difference between the 175 mm length and that snapback length, then dividing the difference by the 175 mm length and multiplying the quotient by 100, as shown in the following equation:

$$\text{Aging Creep \%} = (175_{\text{mm}} - Y_{\text{aged creep}}) / 175 \times 100$$

15 $X_{\text{initial creep}}$ and $Y_{\text{aged creep}}$ readings were taken from the averaged measurements of the 24 strands during the tests.

EXAMPLES

Example 1

20 Amorphous (*i.e.*, atactic) polypropylene (received as slightly yellowish, transparent, elastomeric, small blocks) was obtained from Sigma-Aldrich, a business having offices in Milwaukee, Wisconsin. The amorphous polypropylene had a

weight-average molecular weight of about 28,000 and a number-average molecular weight of 8400 (determined by American Polymer as discussed above). The procured amorphous polypropylene was determined to have a Brookfield viscosity of 23 poise at a temperature of 190 degrees Celsius (determine as described in the Tests/Procedures section above).

Isotactic polypropylene was obtained from Sigma-Aldrich in the form of white, spherical particles. The isotactic polypropylene was determined to have a number-average molecular weight of about 20,000 and a weight-average molecular weight of about 110,000. The procured isotactic polypropylene had a melting index of 1000 grams per ten minutes (at a temperature of 230 degrees Celsius and when subjected to a force of 2.16 kg; see ASTM D 1238, which was used for this determination, for additional detail on measuring the melting index).

Four and ½ kilograms of amorphous polypropylene were added to an adhesive-supply unit; *i.e.*, a hot-melt processing system comprising a hot-melt tank. The adhesive-supply unit was a Dynamelt S Series Model Number DM310, available from ITW Dynatec, a business having offices in Hendersonville, Tennessee. The adhesive-supply unit was set at a temperature of about 370 degrees Fahrenheit. After about one hour the amorphous polypropylene was in substantially liquid form. One-half kilogram of isotactic polypropylene was then added to the already-liquefied amorphous polypropylene. To ensure adequate mixing and uniformity of the resulting blend, a circulatory pump associated with the adhesive-supply unit was activated. The circulatory pump, a gear pump, was operated so that approximately

0.5 to 0.8 pounds per minute of the precursor materials to the uniform blend were circulated. The pump was run for about 1 hour, the time at which the isotactic polypropylene solids were observed to have melted and become uniformly blended with the liquefied amorphous polypropylene.

5 The blend of atactic and isotactic polypropylene was used to bond two substrates together to make laminated structures using the procedures described above. The integrity of the bond between the two substrates was then tested using the 180° static peel test and the dynamic shear and peel tests described above.

Laminates comprising a necked bonded laminate (NBL) and a stretch-bonded laminate (SBL) were bonded together. One set of laminates was made using the atactic and isotactic polypropylene blend, described above, and another set of laminates was made using the commercial elastic attachment adhesive H2800, available from Findley Adhesives, Inc., of Wauwatosa, Wisconsin. In making each of the laminates, the adhesive was meltblown onto one of the substrates at an add-on of 10 grams per square meter (gsm) prior to nipping the two substrates together with the adhesive located between the two substrates.

For each of the sets of laminates, the dynamic shear strength was determined as described above (*i.e.*, one clamp was attached to the top of one substrate of the laminate, and the other clamp was attached to the bottom of the other substrate of the laminate, and the clamps were pulled apart at a constant rate of extension of 300 millimeters per minute). For each of the sets of laminates, the dynamic peel strength was determined as described above (*i.e.*, one clamp was

attached to the top of one substrate of the laminate, and the other clamp was attached to the top of the other substrate of the laminate, and the clamps were pulled apart at a constant rate of extension of 300 millimeters per minute).

Both dynamic shear and peel strength were found to be greater in the polypropylene blend than in the H2800 adhesive. Dynamic shear strength of the NBL/SBL laminate polypropylene blend bonding was determined to be 3600 grams per square inch, compared to dynamic shear strength of the NBL/SBL laminate H2800 bonding which was determined to be 3400 grams per square inch. Dynamic peel strength of the NBL/SBL laminate polypropylene blend bonding was determined to be 1400 grams per inch, compared to dynamic peel strength of the NBL/SBL laminate H2800 bonding which was determined to be 1130 grams per inch.

Additional sets of laminates comprising various combinations of substrates were made using the atactic and isotactic polypropylene blend ("PP blend") and the commercial elastic attachment adhesive H2800. For each of the sets of laminates, the static peel strength was determined as described above (*i.e.*, a 500 gram mass was attached to the upper edge of one of the substrates, with the test panel suspended in an oven at a temperature of 75 degrees Fahrenheit). Results of the static peel strength testing are shown in Table 1 below.

**Table 1: Static Peel Strength of Adhesive Bonds
in Non-Woven Elastic Composites**

Sample	Time to Failure	Observations
NBL/SBL/H2800	2-3 hours	cohesion failure
NBL/SBL/PP blend	> 24 hours	NBL delaminated
NBL/SMS/H2800	~0.5 hour	cohesion failure
NBL/SMS/PP blend	> 12 hours	NBL delaminated
SBL/SMS/H2800	0.5-1.0 hour	cohesion failure
SBL/SMS/PP blend	> 24 hours	SBL delaminated

As can be seen in Table 1, the static peel bonding strength of the blend of atactic and isotactic polypropylene is considerably greater than the static peel bonding strength of the commercial elastic attachment adhesive H2800 in each of the samples tested. Not only did the polypropylene blend consistently achieve longer times to failure than H2800, but the polypropylene blend also never resulted in cohesion failure. Furthermore, the bonded polypropylene blend portions of elastic laminates can be stretchable.

Example 2

A blend of 20% isotactic polypropylene and 80% atactic polypropylene was tested for thermal stability, in the manner described above. For purposes of comparison, the elastic adhesive H2525A, available from Bostik Findley, Inc., of Middleton, Massachusetts, was also tested for thermal stability in the same manner.

The polypropylene blend showed excellent thermal stability. No color, dome, gel, or phasing was observed when the blend aged at 380 degrees Fahrenheit

for 120 hours. The viscosity of the blend was tested before and after aging, in accordance with the procedure described above, and was found to decrease by 4 to 5% after aging. The viscosity of H2525A was also tested before and after aging and was found to decrease by 50% after aging at 375 degrees Fahrenheit for 72 hours.

5 Example 3

A blend of 20% isotactic polypropylene and 80% atactic polypropylene was used to laminate various elastic components at an add-on of 7.5 gsm. The laminates were tested for creeping, in the manner described above. For purposes of comparison, laminates bonded with the elastic adhesive H2525A were also tested for creeping in the same manner.

Creeping of an elastic strand of LYCRA® 940 (available from E.I. Du Pont de Nemours and Company of Wilmington, DE) laminated to a polypropylene spunbonded layer, which was bonded by the polypropylene blend in a melt-blown application, was compared to creeping of the same laminate bonded by H2525A instead. Both the polypropylene blend laminate and the H2525A laminate resulted in 30 to 40% creeping after aging at 105 degrees Fahrenheit for 90 minutes.

Creeping of an elastic strand of GLOSPAN® 1060 (available from Globe Manufacturing Co. of Fall River, MA) laminated to a polypropylene spunbonded layer, which was bonded by the polypropylene blend in a melt-blown application, was compared to creeping of the same laminate bonded by H2525A instead. The polypropylene blend laminate resulted in 5 to 10% less creeping than the H2525A laminate.

Example 4

A blend of 20% isotactic polypropylene and 80% atactic polypropylene was used to laminate various elastic components at an add-on of 7.5 gsm. The laminates were tested for creeping, in the manner described above. For purposes of comparison, laminates bonded with the elastic adhesive H2525A were also tested for creeping in the same manner.

Creeping of an elastic strand of LYCRA® 940 (available from E.I. Du Pont de Nemours and Company of Wilmington, DE) laminated to a polypropylene spunbonded layer, which was bonded by the polypropylene blend in a swirl application, was compared to creeping of the same laminate bonded by H2525A instead. The polypropylene blend laminate resulted in 24% creeping after aging at 105 degrees Fahrenheit for 90 minutes, while the H2525A laminate resulted in 55 to 60% creeping after aging at 105 degrees Fahrenheit for 90 minutes.

Creeping of an elastic strand of GLOSPAN® 1060 (available from Globe Manufacturing Co. of Fall River, MA) laminated to a polypropylene spunbonded layer, which was bonded by the polypropylene blend in a swirl application, was compared to creeping of the same laminate bonded by H2525A instead. The polypropylene blend laminate resulted in 20% creeping, while the H2525A laminate resulted in 60-70% creeping.

It will be appreciated that details of the foregoing embodiments, given for purposes of illustration, are not to be construed as limiting the scope of this invention. Although only a few exemplary embodiments of this invention have been

described in detail above, those skilled in the art will readily appreciate that many modifications are possible in the exemplary embodiments without materially departing from the novel teachings and advantages of this invention. Accordingly, all such modifications are intended to be included within the scope of this invention, which is defined in the following claims and all equivalents thereto. Further, it is recognized that many embodiments may be conceived that do not achieve all of the advantages of some embodiments, particularly of the preferred embodiments, yet the absence of a particular advantage shall not be construed to necessarily mean that such an embodiment is outside the scope of the present invention.

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